Methods for Analyzing Group Problem Solving Decision Making

Ute M. Fischer
Vassar College

Research and Advanced Concepts Office
Michael Drillings, Acting Director

May 1996

DTIC QUALITY INSPECTED 4

19960813 127

United States Army
Research Institute for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

**A Field Operating Agency Under the Jurisdiction
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EDGAR M. JOHNSON
Director

Research accomplished under contract
for the Department of the Army

Vassar College

Technical review by

Guy Seibold

REPORT DOCUMENTATION PAGE

1. REPORT DATE 1996, May	2. REPORT TYPE Final	3. DATES COVERED (from. . . to) June 1990-January 1991

4. TITLE AND SUBTITLE Methods for Analyzing Group Problem Solving Decision Making	5a. CONTRACT OR GRANT NUMBER DAAL03-86-D-0001
	5b. PROGRAM ELEMENT NUMBER 0601102A

6. AUTHOR(S) Ute M. Fischer (Vassar College)	5c. PROJECT NUMBER B74F
	5d. TASK NUMBER 1901
	5e. WORK UNIT NUMBER C48

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Vassar College Cognitive Science Program P.O. Box 283 Poughkeepsie, NY 12601	8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: PERI-BR 5001 Eisenhower Avenue Alexandria, VA 22333-5600	10. MONITOR ACRONYM ARI
	11. MONITOR REPORT NUMBER Research Note 96-64

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

COR: Michael Drillings

14. ABSTRACT *(Maximum 200 words)*:

This paper describes two methods for analyzing cockpit discourses. One coding scheme was developed to characterize the functions of crew discourse within a problem solving and decision making context. A second method is concerned with the conversational coherence of crew discourse. Both methods complement each other in describing how crews establish through language-shared mental models for the situation.

15. SUBJECT TERMS

Functional analysis of discourse   Conversational coherence

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified	Unlimited	11	

This paper describes methods for analyzing how airplane crews use language in their effort to resolve an emergency situation. The proposed coding schemes can then be used to characterize differences between high and low performing crews.

When a problem occurs during flight, a decision has to be made as to what the best plan and strategy is to solve the problem. Decisions in this context are, as Orasanu (1990) points out, subject to considerable time constraint, and might have severe consequences. Furthermore, situational variables might change over time, and thus render a previously acceptable decision inadequate. Although the primary responsibility for a decision is with the captain, all crew members are involved in the processes that lead to a decision. In order to insure that the right decision is made and acted upon at the right time, crew members have to communicate to each other how they perceive and interpret the situation, what they think could and should be done and what each member's responsibilities are.

Communication between the crew members is thus functional in two respects. On the one hand, it is an integral part of the decision process. That is to say, utterances fulfill particular functions within the decision process. For instance, a speaker may alert his addressee to a problematic aspect of the situation, define a problem, or request information. Furthermore, by articulating their assessment of the situation and expressing plans, etc., crew members establish a common or shared understanding of the problem. Communication therefore plays a crucial role in building shared mental models for the situation which, in turn, render utterances meaningful.

Functional Analysis of Crew Discourse

Given that the communication between crew members plays an integral part of their decision process, their language should map onto components that have been found essential to problem solving and decision making in a natural context. Naturally occurring problem solving and decision making is characterized by the following elements (Orasanu,1990). In order to solve a problem and reach an appropriate decision, one has to recognize that a problem exists and identify what the problem is, and set goals and subgoals. Furthermore, one has to decide on plans and strategies to achieve the goals and subgoals which often necessitates that further information is obtained. In dynamically changing situations, successful problem solving requires an awareness of future events and possible problems. And lastly, given a problem solving context that involves several people, explaining why certain plans or actions are taken, makes the situation more transparent to the participants and facilitates their cooperation.

Based on this list, the following functions of utterances were discerned:
- Problem recognition and definition
- Goal/subgoal statement
- Plan/strategy statement
- Request for information
- Alerting and predicting
- Explanation.

These functions constitute what has been called Metacognitive/Problem Solving Talk (Orasanu, 1990).

A second type of crew discourse was distinguished that is not directly relevant for the problem solving and decision making process but supportive of it. Utterances in this category serve the purpose of resource management. Speakers signal their availability/unavailability for performing some task, allocate duties among the participants, or reflect sensitivity to time constraints. Also included in this category are communications with the ground, stewardesses and passengers.

The last category of crew discourse that was identified, comprises utterances that are simple commands or monitor the crew's actions and the status of instruments. These utterances are part of the standard procedure of flying a plane. Standard operating procedures talk is formulaic, and reoccurs across crews at the same times. Observations and evaluations of the situation that are not relevant to the problem solving situation were also subsumed into this category.

Validating the Coding Scheme

The coding scheme for the functions of crew discourse was validated on transcripts of the communication of eighteen two-member crews and of eight three-member crews in a flight simulator. Given the focus on the functional role of language in a problem solving context, only initializing

utterances, i.e., utterances that introduced a new topic, were coded. Thus, requests for repetition due to inaudible speech and answers that did not provide any further information than mandated by the initializing question, were not coded. Utterances were coded by speaker. For the two-member crews it was noted whether an utterance with a particular function was made by the captain or the first officer. For three-member crews the functional codes were broken down by captain, first officer, and second officer.

The basic unit of analysis was a clause. For example, the utterance *I wanna know how far we are so I can get down there* consists of the two clauses *I wanna know how far we are* and *so I can get down there.* But, at times, the segment could be larger as in utterances that express a contingency plan (*If we have to go on a missed approach, how about setting Flatrock on your side and Richmond on my side),* or smaller, consisting of only part of a clause, for example the *Tell'em* in the utterance *Tell'em we want immediate clearance to Roanoke.*

Each clause was assigned only one function. If a clause could serve several functions, it was coded on the highest functional level. For instance the utterance *Let's check our runway charts* forms a command but, on another level, it expresses a plan. Since a plan statement is functionally more important in a problem solving context than a simple command, the utterance was coded as a plan statement.

Codes could be embedded within each other. Embedded coding, however, was restricted to utterances that initiate communication with the ground, the stewardesses, and the

passengers. For example, the utterance *Tell'em we want immediate clearance to Roanoke* initiates communication with the company and, embedded in it, makes a goal statement.

Inter-rater Reliability

Inter-rater reliability for the coding of the two-member crews was achieved in two ways. Ten transcripts were independently coded by three raters, and disaggreements were resolved through discussion. The remaining eight transcripts were coded by one rater. For each transcript, the 150 utterances following the first recognition of the hydraulic problem were selected and coded by a second rater. Inter-rater reliability varies between 66% and 71% aggreement. Disagreements, however, are very systematic and concern mainly the coding of commands versus plan statements, and the providing of information versus monitoring the status of instruments. Thus, they can easily be resolved through discussion or through the judgment of a third rater.

Conversational Coherence of Crew Discourse

The functional analysis of crew discourse focuses on the role that individual utterances play in the problem solving and decision making process. In particular, it attempts to analyze how utterances contribute to shared mental models for the situation. However, by concentrating on individual utterances the functional analysis is not sufficient for characterizing how crew members establish a common understanding of the

situation. Clearly, participants in a discourse do not simply take turns in producing utterances. Speakers want to make themselves understood, and their listeners have to signal them that they have succeeded in doing so. Discourse therefore consists of structured sequences of utterances (Clark & Schaefer, 1989). Questions require answers, commands need to be acknowledged or rejected, statements are confirmed or disconfirmed. Thus, making metacognitive/problem solving talk is one step towards building shared mental models. If the addressee does not take notice of it, it fails to achieve its intended function. Accordingly, the functional analysis of the crew discourse was complemented by an analysis of its conversational coherence.

In order to characterize conversational coherence, the following eight categories of continuations were discerned:

- Answer
- Confirmation
- Repetition
- Thematic Continuation
- Action
- Question
- Correction
- None

Confirmations, repetitions, thematic continuations, and actions are all forms of acknowledgements. Listerners can acknowledge a statement or command of the speaker by responding with short utterances such as *ok.*, or by repeating it. Commands can also be acknowledged by simply performing the required action. Listeners can acknowledge statements by

taking over the turn with a thematically related statement. They can disconfirm a statement by responding with a statement that corrects information provided by the speaker. Answers can follow only questions. Questions can follow questions, commands, or statements, and indicate the need of the listener for additional information in order to respond adequately to the speaker.

One of the above continuations was assigned to each utterance that had previously been given a functional code. A no-response to an utterance was coded as *none.* If an utterance had several codes associated with it, two possibilities existed. The continuation was assigned to the last functional code when the functional codes were of the same level of importance. If the functional codes referred to different functional levels, then continuation was noted for the functional code at the highest functional level. For instance, the confirmation of an utterance that consisted of a plan statement plus an explanation, was assigned to the plan statement.

In two-member crews, it is clear who the addressee of a given utterance was. However, the situation is ambiguous in three-member crews. There are two listeners. It was therefore necessary to specify, in addition to the type of continuation, who the response gave.

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